Assessing the Financial Risks and Buffers of the Central Bank

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Abstract

The global financial crisis brought about significant changes in the size and composition of euro area national central banks' (NCBs) balance sheets, and led to substantially increased financial risks. Realised losses can have negative consequences for the independence, policy effectiveness and credibility of central banks and thus, in recent years, NCBs have been paying much closer attention to the measurement of risks on their balance sheet, and to the appropriateness of their financial buffers. This includes increasing the scope of risk measurements, enhancing risk measurement tools, and expanding the actions taken to mitigate risks. The Central Bank of Ireland (the Central Bank) has similarly developed its risk measurement tools and practices during this period. This includes the introduction of risk provisions, and the introduction of a broader framework to facilitate a more risk-based assessment of the Central Bank's financial buffers position. The framework's use of stress scenarios, as well as the application of a multi-year, dynamic balance sheet approach to estimating the Central Bank's risks, serves as an important guide to determining the adequacy of capital and reserves– thereby helping to preserve financial independence.

1. Introduction

While the structure and activities of central banks differ, in general they are exposed to similar financial risks to their commercial counterparts; including market and credit risk on securities, credit risk on lending to counterparties, interest rate mismatch risk, and exchange rate risk on currency exposures. The risk and return trade-offs are different for central banks, whereby the generation of large profits is usually not the primary objective in the management of public funds. Subject to preserving the value of funds invested and maintaining liquidity in its investment assets, central banks will generally aim to generate a profit. While central banks are typically conservative, they are also often exposed to further financial risks associated with implementing monetary policy; for example, risks arising from asset purchases. Given the typically conservative risk appetite, and policy mandate, NCBs pay close attention to their risk controls and risk management framework, and monitor the risks to their balance sheet. While such measures are broadly effective, central banks do take risks and therefore losses can and do arise. To mitigate against potential balance sheet losses, Eurosystem NCBs aim to hold a certain level of 'financial buffers', similar to commercial banks.[2]

Following the onset of the financial crisis, the risks facing many NCBs increased substantially, the scale and speed of which meant that financial risk buffers also needed to increase substantially to cover potential losses. Some observers may question why central banks actively manage or aim to mitigate such risks via financial buffers, when they could, in theory, operate with negative capital due to the long-term ability to create funds on their own account and generate seignorage income.[3] Indeed, there are empirical examples of central banks that have effectively implemented policy whilst operating with negative capital. [4]

These examples do not however preclude potentially undesirable repercussions for central banks with consistently negative capital positions. While membership of a monetary union for central banks in the euro area may cloud the materiality of some of the potential policy disadvantages from operating with low or negative capital – given that policy is set by the Governing Council of the ECB – euro area NCBs would not be immune from the associated reputational and credibility risks. Furthermore, questions may arise as to the consequences for domestic financial stability and the (actual or perceived) fiscal strength of the country in question, depending on the length of time it took for the respective government to recapitalise the NCB.

Taking these considerations into account, many NCBs have enhanced their risk assessment methodologies and taken steps to increase their financial buffers, such as through enhanced levels of reserves and risk provisions. Similarly, the Central Bank has, since 2008, retained the maximum amount of annual profits permissible after distributions to the exchequer - 20 per cent - which has been transferred to its general reserve to build up financial buffers. In addition, the Central Bank has expanded its risk assessment methodologies and processes and has introduced suitable risk provisioning measures.

The remainder of the paper is structured as follows: Section 2 considers financial risk and buffers in the context of central bank balance sheets generally; Section 3 looks at how the Central Bank measures financial risks; Section 4 examines the framework and methodologies for modelling financial risks in the Central Bank, while Section 5 concludes.

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2 This paper uses the terms 'capital', and 'financial buffer' interchangeably to refer to any combination of capital, reserves (e.g. retained earnings) and provisions, all of which are considered to be effective in absorbing losses. While revaluation accounts can act as a financial buffer, they are not included as such in this paper as they cannot be controlled by a central bank and instead are created due to price movements.

3 Seignorage income can narrowly be defined as the difference between the income or value of currency issued, less the cost of issuing or minting the currency. More broadly, however, seignorage income can be extended to include the income that central banks make from investing the proceeds of currency issuance.

4 For instance, the Czech National Bank and the Central Bank of Chile (see Archer and Moser-Boehm, 2013).

2. Financial Risk and Buffers Assessments

2.1 Why should a central bank hold adequate financial buffers?

Starting with the counter argument, there are two well established arguments as to why central banks, generally, should not need to hold capital; (i) the absence of liquidity constraints due to the monopoly supply of currency, which (theoretically) ensures long run profitability, and (ii) the presumption of fiscal support due to the (general) State ownership of central banks.[5] There are, however, some questions around the validity of these arguments. In particular, the conditionality and extent of government support varies across different institutions, and cannot be guaranteed in perpetuity due to the changing nature of governments and fiscal positions over time. The timeframe within which this recapitalisation should take place is also unclear. While there are nuanced considerations that apply to central banks in a monetary union, such as whether the policy effectiveness of a euro area NCB would be questioned to the same degree as non-monetary union central banks given the role of the ECB, the arguments presented here nonetheless apply to NCBs. In addition, the ECB has stated that NCBs must always be sufficiently capitalised (ECB, 2018a).

Aside from these uncertainties, there are three broader arguments that favour the maintenance of financial buffers by central banks:

(i) Independence
It is generally accepted that central banks should seek to be independent from their governments in order to maintain a clear distinction between the spending of money and money creation, and to maintain policy independence. Institutional and legal arrangements for a central bank are often constructed to support this distinction; however, as noted by Ivanović (2014), "Financial independence is the key element of central bank's full independence".

In the case of weak financial strength, a central bank may require fiscal support from the government. This raises the possibility of the government seeking to influence central bank policy, potentially in response to political pressure, thus introducing a short-term perspective to decision-making. Ivanović suggests that, in the case of a central bank requiring support from the fiscal authority, the political establishment could interfere in order to prevent the central bank from pursuing policies that may compound losses, thus curtailing its independence. In short, the necessary distinction between fiscal and monetary policy is made possible by central banks' financial and operational independence from the prevailing political regime.

(ii) Effect on policy
Insufficient capital may also create a conflict between a central bank's monetary policy objectives and efforts to avoid negative capital levels. While a central bank could create money with the intention of recapitalising through higher seignorage revenues, doing so could be at the expense of policy objectives, e.g. it could lead to undesirably high inflation. On this point, Stella (1997) concludes that "Central banks need not have capital or even positive net worth to function. However, seriously deteriorated balance sheets causing chronic losses will eventually interfere with price stability". Specifically, he lists possible actions that a severely weakened balance sheet would demand: the abandonment of inflation control; the repression of the financial system; reliance on interventions from the treasury; or recapitalisation. All of these actions may result in a material diminution in the capacity for a central bank to perform its normal functions.

(iii) Credibility
The reputational impact of negative capital is another important consideration. As Bindseil, Manzanares and Weller (2004) argue, the central bank's status as an unlimited source of money (and

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5   Bindseil et. al. (2004) argue: 'A government re-capitalisation rule would only be a full substitute for capital in this regard if it is unconditionally automatic.'

by extension, its theoretical ability to operate with negative capital) is dependent on public trust in the value of this money, and therefore on the reputation of the central bank itself. Archer and Moser-Boehm (2013) conclude that "Losses or negative capital may raise doubts – however erroneous – about the central bank's ability to deliver on policy targets, and expose it to political pressure". Buiter (2015) notes that counterparties may become reluctant to deal with a technically insolvent central bank, with such a scenario potentially affecting a central bank's ability to implement monetary policy.

Some of these arguments may also apply in the situation of a central bank experiencing losses that do not completely deplete available buffers; in particular, the credibility of the central bank may be affected. This link between losses and credibility is referenced by Bunea *et. al.* (2016), who argue that 'While they are not a measure of central bank performance, in the long run profits strengthen the credibility of central banks'.

Furthermore, Hall and Reis (2015) consider the use of non-standard monetary policy measures to be a 'new style central banking', where central banks borrow from commercial banks by expanding reserves, and use the proceeds to purchase risky assets. This has led to greater risks, including interest rate and default risk, which may result in negative income for the central bank. The authors note that negative central bank income may lead to payments from the government to the central bank or, if no fiscal support were in place, the issuance of endless amounts of reserves.

In summary, there are clear arguments for maintaining positive financial buffers: to preserve financial independence, to ensure effective monetary policy and to retain credibility. The next consideration, therefore, is what level of financial buffers is suitable?

2.2 Measuring the required level of financial buffers

As indicated by Milton and Sinclair (2011), if a central bank's capital level is too low, the insurance against possible losses would be too small. However, if too much capital is held, there may be an opportunity cost as the funds retained could perhaps be put to better use by the State. They acknowledge that, in reality, the determination of this theoretical equilibrium is far from straightforward. On a similar note, Rule (2015) suggests that there is no straightforward, correct answer as to the 'optimal' level of capital for a central bank; instead, it is dependent on a number of factors including its institutional structure and the types of operations it undertakes.

Nonetheless, some central banks do attempt to define an appropriate level of buffers using approaches such as capital adequacy ratios, with Value-at-Risk (VaR) type analysis and more general frameworks also highlighted as possible methods (Archer and Moser-Boehm, 2013). More recently, the Bank of England (BoE) has announced a new financial risk framework, which sets out a number of parameters within which the BoE financial buffers are determined. This framework, agreed between the BoE and HM Treasury, sets out how BoE will be provided with the resources required to carry out the monetary and financial stability responsibilities it has been assigned. It includes a framework for determining the BoE's required capital, any capital input required from HM Treasury, and how the BoE will distribute or retain profits in circumstances where its capital is above or below threshold levels. The central anchor of the framework is a target level for the BoE's capital. The target is to be calculated using a forward-looking, scenario-based approach to assess potential losses in a set of severe but plausible events, for activities that are backed by the Bank's capital (HM Treasury, 2018).

Overall, it is clear that there are several qualitative factors that influence a central bank's capital levels, as well as quantitative elements (e.g., size and risk profile of the asset base). Nonetheless, the Central Bank has taken further steps over recent years to help ensure a sufficient level of financial buffers are held. This includes the implementation of an enhanced capital assessment framework to help measure risks and identify an appropriate level of financial buffers.

3. Measuring the Central Bank of Ireland's Financial Risks

3.1. Central Bank of Ireland Exposures and Risks

As noted, the measurement of risks is central to assessing an appropriate level of buffers. The Central Bank is exposed to various degrees of market and credit risks through monetary policy operations, investment portfolio holdings, and through any holdings of securities purchased for monetary policy purposes.

During normal times, these exposures, and risks, are relatively small, but can increase rapidly in line with measures taken to meet price and financial stability policy objectives. For instance, the Central Bank's balance sheet increased substantially during the global financial crisis, primarily due to increased monetary policy-related lending to Irish counterparties, as well as the provision of emergency liquidity assistance (ELA). Any provision of ELA is at the own risk of the lending NCB. As set out in the ECB's Agreement on emergency liquidity assistance (ECB, 2017a), the main responsibility for the provision of ELA lies with the NCBs concerned. The Special Portfolio that remains on the Central Bank's balance sheet stems from that period of exceptional liquidity assistance to banks as it arose following the liquidation of IBRC.[6]

In addition, more recent large-scale asset purchases have resulted in further expansion of the balance sheet, and the emergence of a risk of a significant interest rate mismatch. This potential mismatch arises from the fact that securities purchased under the ECB's Asset Purchase Programme (APP) were at historically low, fixed rates, while increased liabilities associated with these purchases are linked to variable policy rates. Consequently, the Central Bank is at risk of experiencing decreases in its Net Interest Income (NII), in the event of a significant increase in euro area policy rates (Donnery *et. al.*, 2017).

The stylised balance sheet in Figure 1, illustrates how risks change in line with changes in the balance sheet over time. Chart 1 shows that the Central Bank's balance sheet increased five-fold between 2006 and 2010, reaching over €200bn in 2010. A subsequent reduction, as the crisis abated, has since reversed following the purchase of large amounts of assets under the ECB's APP, with the balance sheet reaching approximately €90bn as at end-2017.

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6   The Central Bank acquired a 'Special Portfolio', comprising Promissory notes, a fixed rate Irish Government Bond, Nama bonds, and a small amount of other assets. The Promissory Notes were exchanged for a portfolio of floating rate notes (FRNs). See CBI (2015) for more information.

Figure 1: Stylised Central Bank of Ireland Balance Sheet

NORMAL TIMES

	Assets	Liabilities
Credit risk/Market risk ▶	Investment portfolio	Banknotes Capital and reserves
Credit risk ▶	Monetary Policy Operations	Deposits

Limited interest rate mismatch

FINANCIAL CRISIS 2008-2014

	Assets	Liabilities
Credit risk/Market risk ▶	Investment portfolios	Banknotes Capital and reserves
Credit risk ▶	Monetary Policy Operations	Deposits
Credit risk* ▶	ELA/Special Portfolio	Target 2
Credit risk ▶	Securities for mon. pol	

Limited interest rate mismatch

2015 to PRESENT

	Assets	Liabilities
Credit risk/Market risk ▶	Investment portfolios	Banknotes Capital and reserves
Credit risk/Market risk ▶	Special Portfolio	Deposits
Credit risk ▶	Monetary Policy Operations	
Credit risk ▶	Securities for mon. pol	

Moderate interest rate mismatch

* Market risk also applied to the Special Portfolio

Chart 1: Central Bank of Ireland Key Financial Exposures 2005 - 2017
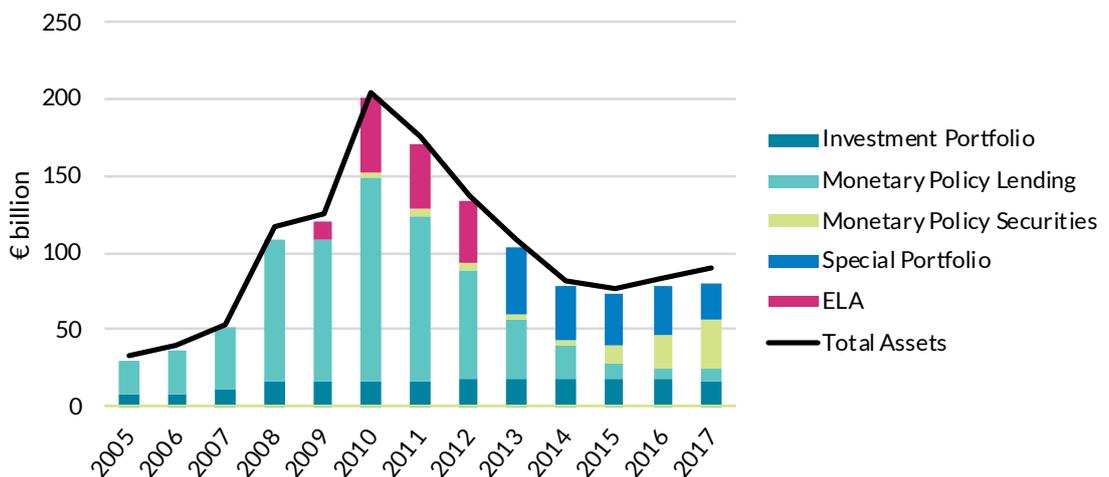
Source: Central Bank of Ireland Annual Reports

3.2. Central Bank of Ireland Measurement of Own Risks

As part of the framework for managing its risks, the Central Bank measures and models its financial risks through a number of different channels, using models and methodologies that are widely used within the financial industry to measure credit and market risks. Certain adjustments, however, are required to reflect the bespoke nature of central banking accounting rules. For instance, unrealised losses are recognised in the profit and loss account, while unrealised gains are instead written to revaluation accounts. As a result, the estimated risks are considered as residual losses after revaluation accounts have been considered, and the risk calculations reflect this.

The risk arising from the interest rate mismatch referenced earlier is measured using an internally developed Asset Liability Management (ALM) model. This model estimates the balance sheet over the next ten years, using assumptions based on historical trends, forward guidance and internal policies, with expert judgement also incorporated. A large number of interest rate path scenarios are inputted into the model, allowing the interest income and expense of the various elements of the balance sheet to be calculated for each scenario and risk measurements to be obtained.

3.3. Measuring Adjusted Risk Exposures – Shared Risks

A unique feature of central banks in the Eurosystem is the sharing of income and losses on certain monetary policy operations between the NCBs. While the Central Bank's balance sheet records the value of assets and liabilities held at a particular point in time, this does not fully reflect the risks to which the Central Bank is exposed. Instead, adjustments must be made to account for the loss sharing arrangements in the Eurosystem (see Table 1), whereby losses arising from decentralised monetary policy operations conducted by the Eurosystem are generally shared by the NCBs in proportion to their prevailing ECB capital key shares (the percentage of paid up capital provided by that NCB). The Central Bank's capital key share is 1.65 per cent[7].

In particular, losses that may arise from certain outright purchase programmes (securities held for monetary policy purposes) are shared. These include the securities markets programme (SMP) (see Alvarez *et. al.*, 2017), the corporate sector purchase programme (CSPP) (ECB, 2018b), and the third covered bond purchase programme (CBPP3) (ECB, 2017b). In addition, any losses on a certain proportion of the public sector purchase programme (PSPP) are shared (ECB, 2018c). Losses arising on other portfolios of bonds held for monetary policy purposes are not shared, including losses on the first or second corporate bond programme (CBPP1/2) [8] (see Alvarez *et. al.*, 2017) and purchases of domestic jurisdiction government bonds under the PSPP programme (ECB 2018c).

With regard to monetary policy lending, all standard monetary policy lending operations are loss shared, once the collateral used by the borrowing counterparties meets the required eligibility criteria (ECB, 2015a). Any losses arising from lending against collateral that does not meet these requirements are borne solely by the respective NCB (Nagel, 2012; Central Bank, 2018). For example, the Central Bank is one of a number of NCBs, which have Additional Credit Claims (ACC) frameworks in place (ECB, n.d.). This framework, which is temporary in nature, allows the Central Bank to accept as collateral certain credit claims that do not comply with the general Eurosystem eligibility rules and/or credit quality standards. Other assets on NCBs' balance sheets, including investment holdings, are held at the NCB's own risk.

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7 The capital of the ECB is provided by the central banks of all EU Member States and currently stands at €10.8bn. The amount contributed by each central bank is calculated based on the relevant country's population and GDP. Of this capital, only the portion attributable to the euro area NCBs is fully paid up, amounting to €7.6bn. See ECB (2015b).

8 CBPP 1 and 2 have ended and no balances remain outstanding on the Central Bank's balance sheet.

Table 1: Risk Shared Exposures for the Central Bank

Key Exposures (euro billion)	Risk Sharing
Lending to euro area credit institutions *(related to monetary policy operations)*	Yes
Securities held for monetary policy purposes	
Securities Markets Programme	Yes
Covered Bond Purchase Programme 3	Yes
Public Sector Purchase Programme	Mixed
Corporate Sector Purchase Programme	Yes

Chart 2, presents the historical differences between the published and adjusted risk exposures of the Central Bank. Currently, the difference between these is driven primarily by the CSPP, which is not held on the Central Bank balance sheet.

Chart 2: Central Bank of Ireland Published and Adjusted Risk Exposures
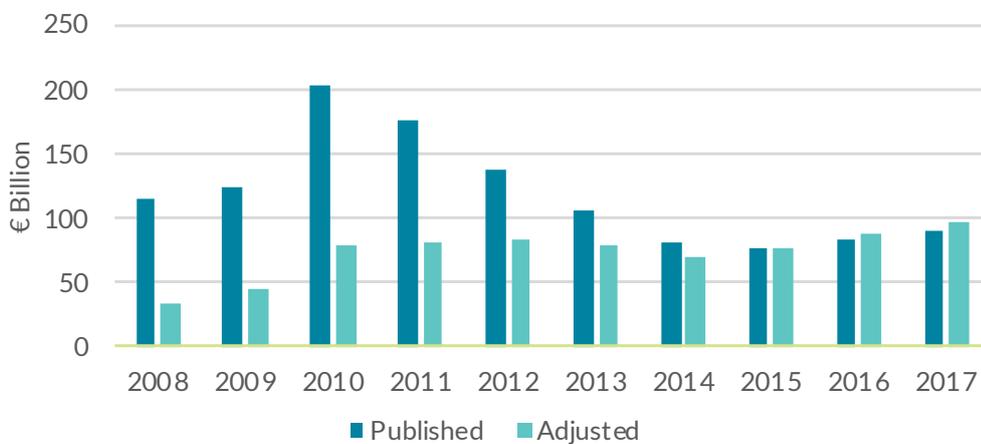
Source: Central Bank Annual Reports, ECB data, Central Bank of Ireland calculations

3.3.1 Sharing of ECB Profit and Losses

Another consideration with regard to loss sharing is potential losses experienced by the ECB. According to Article 33.2 of the ESCB Statute, "...in the event of a loss incurred by the ECB, the shortfall may be offset against the general reserve fund of the ECB and, if necessary, following a decision by the Governing Council, against the monetary income of the relevant financial year in proportion and up to the amounts allocated to the national central banks". This indicates that ECB losses could lower potential profits for the Central Bank during that fiscal year and, as such, can be construed as an indirect loss for the Central Bank. [9] In recent years, the ECB has accumulated a significant amount of buffers to offset any potential losses.

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9   For example, this mechanism was utilised in 2004, where the ECB made a net loss of €1.6bn.See ECB, (2005).

3.4 The Central Bank of Ireland's Financial Buffers

While the Central Bank employs active measures to mitigate risks, including rating thresholds, limits and implementation of Eurosystem risk management frameworks; it also seeks to maintain a level of financial risk buffers to absorb losses that may arise under certain circumstances. These buffers primarily consist of capital, reserves and any provisions set aside relating to certain financial risks. In addition, both revaluation accounts and profits in a given year can be used to offset losses.[10] However, as both can deplete quickly due to market fluctuations, they are generally considered less useful as a financial buffer.

The issued and paid-up capital of the Central Bank is €30,474.00, which is held by the Minister for Finance. Reserves are created by the retention of a portion of the Central Bank's profit, the remainder of which is distributed to the Exchequer. This is governed by the Central Bank of Ireland (Surplus Income) Regulations (1943), which requires the Central Bank to transfer a minimum of 80 percent of its profits in any given year to the State - meaning a maximum of 20 percent can be transferred to the general reserve.

Following the recent increase in the balance sheet size and associated financial risk, the Central Bank sought to increase its financial buffers accordingly, to ensure it maintained appropriate levels of financial resilience (Chart 3). To this end, the maximum 20 per cent of profits were transferred to the general reserve between 2008 and 2017, resulting in capital and reserves of €4.2bn as of end-2017.[11] In addition, in 2016 the Central Bank established a general risk provision (GRP) to mitigate against the previously discussed potential interest rate mismatch on the balance sheet. A provision for securities has been maintained since 2012.

Chart 3: Central Bank of Ireland Financial Buffers
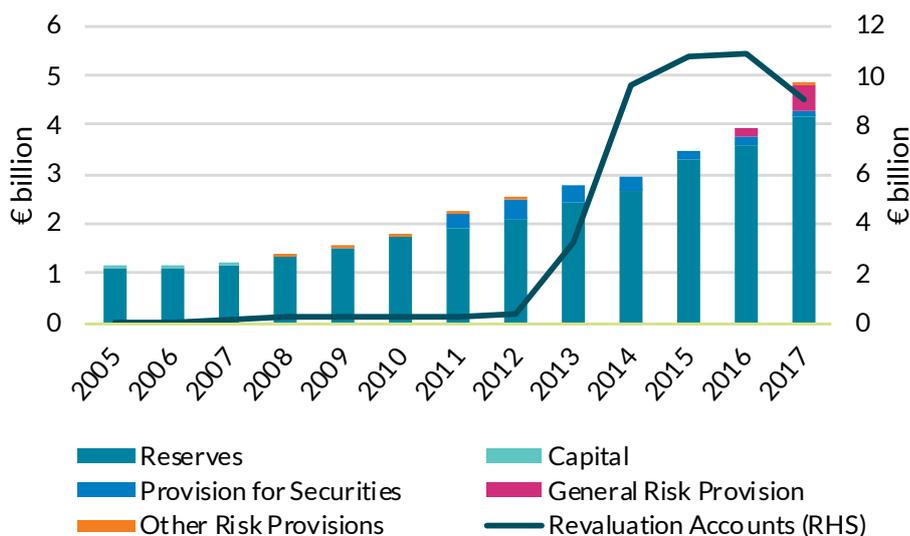
Source: Central Bank of Ireland Annual Reports

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10 Revaluation accounts can only offset losses for the specific instrument they are held against; i.e., revaluation gains held against one instrument cannot be used to offset losses in another instrument.

11 Over the same period, the Central Bank transferred over €12bn to the Exchequer in line with regulations.

4. A Framework for Assessing the Central Bank of Ireland's Financial Buffers

The Central Bank, in recent times, has enhanced its framework for the assessment of its financial buffers, to help preserve its financial independence. In determining the appropriate capital assessment framework, two key considerations presented themselves, namely whether to utilise the size of the nominal balance sheet as a basis for determining capital adequacy or whether to adopt a risk-based assessment and, secondly, whether to assess the balance sheet on a static or forward-looking basis.

(i) Nominal balance sheet size or risk-based assessment?
While there can be operational and communication benefits to simply setting capital and reserves based on the nominal size of the balance sheet, this does not ensure an adequate link between the level of buffers and the potential for losses. Therefore, a risk-based assessment was considered a more suitable approach.

The Central Bank's introduction of a GRP framework for the 2016 annual accounts helps in this regard, as it enables funds to be put aside for the purpose of building financial buffers against identified probable losses (See Box 8, Central Bank of Ireland, 2017). The Central Bank's internal policies on GRP, however, do not allow provisioning in excess of the specific conditions set out in the GRP policy. This means that the risk-based estimation of overall capital and reserves is a key component of the management of the Central Bank's buffers.

(ii) Static or forward-looking balance sheet assessment?
Risk measures, particularly when used to assess financial risks in an accounting context, tend to utilise a one-year horizon. This is a valid horizon for a number of reasons, including accounting convention and increased uncertainty beyond that point.

Over the medium- to long-term horizon, however, an NCB's risk profile can change substantially, and may increase, as it undertakes actions relating to its mandates (as has been the case with the introduction of the APP). At the same time, NCBs may be limited with regard to how quickly they can accumulate capital and reserves, meaning a sudden build-up of risks could leave a NCB unable to cover losses, should they materialise. Therefore, a forward-looking and dynamic risk assessment approach, using a medium- to long-term horizon, was considered appropriate when assessing the required capital and reserves.

4.1. Determination of recommended capital level

To incorporate these considerations, the Central Bank's enhanced capital assessment framework includes an annual exercise whereby one or more scenarios are calibrated over a five-year timeframe and the potential associated risks to the Central Bank's balance sheet are modelled. Where appropriate, the Central Bank's current risk provisions are added to the capital assessment results to identify the overall level of recommended buffers. Where the overall risk measures point towards potential capital requirements that are in excess of the Central Bank's existing levels of buffers, the Central Bank will seek to retain profits and/or record provisions (as per Section 3.4) in order to build up its buffers.

In determining what the appropriate level of capital should be, the Central Bank considers the scenarios modelled, their probability of occurrence, and the likely magnitude of losses. Additionally, a qualitative and professional judgemental overlay is also incorporated into the risk modelling process and overall profit retention decision. The framework allows for circumstances where, following a build-up of risks and associated buffers, conditions improve and a reduction of buffers may be warranted. Buffers in the form of provisions must be released in the event that the identified risk has

not been realised or the probability of the risk occurring has become negligible. Given that there may be uncertainty as to the future reduction in risks, however, greater discretion is provided for in the case of any risk-implied reduction in the general reserve, with expert judgement incorporated to avoid a reduction that may prove to be premature.

4.2. Modelling of Scenarios within the Capital Assessment Framework

As noted, the framework for assessing the adequacy of the Central Bank's capital and reserves uses stress scenarios to obtain the potential changes in the Central Bank's risk profile under extreme yet plausible stress events, over a five-year horizon. This process focuses on the market and credit risks associated with the Central Bank's exposures, whereas the interest rate mismatch risks and other provision calculations are modelled separately and then considered jointly in the overall assessment of risks and buffers.

A cross-Central Bank working group, coordinated by the Organisational Risk Division's Financial Risk Management Function and comprising experts from across the Central Bank, considers and calibrates appropriate risk scenarios that are then approved by the Central Bank's risk management governance structures. The scenarios assessed within the framework describe hypothetical risk events of varying magnitude and severity, which may occur over a five-year horizon. A baseline scenario is also constructed, which contains assumptions for both expected balance sheet exposures and market conditions. Figure 2 displays the structured process followed during the development and modelling of the stress scenarios.

Figure 2: Methodology for modelling risk under stress scenarios
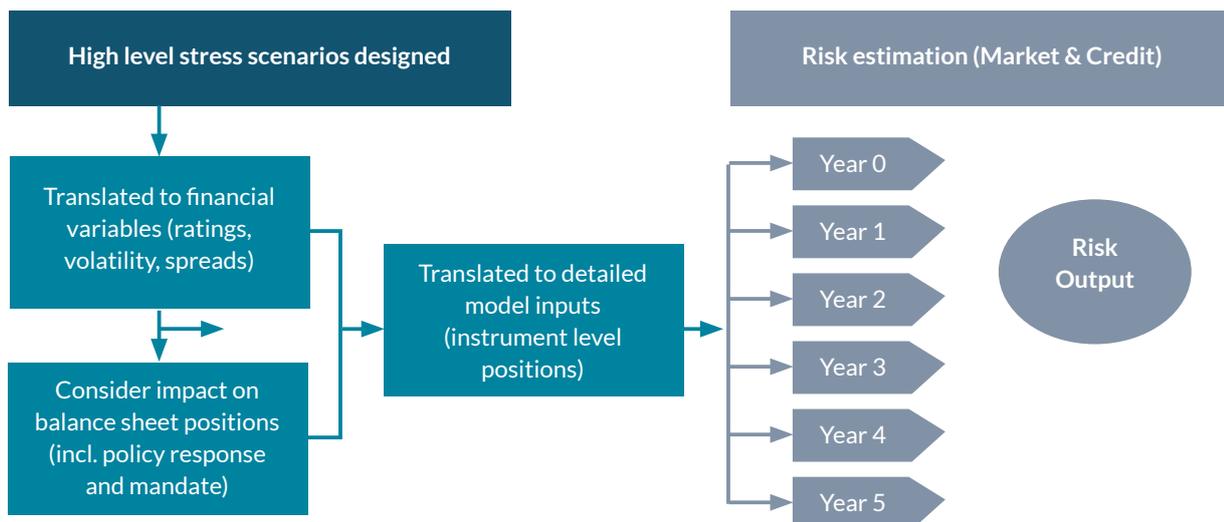
In developing the stress scenarios, the following three principles are considered to be essential:

(i)   the scenarios should be plausible, but sufficiently adverse to provide useful information;

(ii)   the scenarios should be informed based on the current risk sensitivities of the Central Bank and available economic and market data;

(iii)   the scenarios should consider the evolution of the Central Bank's balance sheet and potential policy action linked to the Central Bank's mandate.

Following this, possible events that may result in adverse movements in key risk variables and exposures are considered (including contagion), along with the likelihood of these events. The scenarios are then mapped and translated to financial variables, such as credit rating migrations, volatility shocks and spread movements. To ensure plausibility, shocks to these variables are assessed with reference to historical time periods and expert judgemental overlay applied.

Future changes to the Central Bank's balance sheet are also included to more accurately measure the potential risk. These changes are based on current information (e.g. ECB forward guidance), but are also adjusted for consistency with the scenario under consideration, including any increases in exposure due to possible policy responses to the underlying stress scenario.

The dynamic nature of these scenarios allows for the examination of the possible evolution of the Central Bank's risk profile over a medium- to long-term horizon and provides a methodology by which risk associated with the Central Bank's off-balance sheet commitments (i.e. Eurosystem shared risks or risk relating to exposures, which are not currently on the balance sheet) can be measured. These off-balance sheet commitments may not always be apparent during benign periods, but may develop quickly in situations that are more adverse.

In order to model the risks associated with the proposed scenarios, these financial and balance sheet variables are parameterised and mapped to granular model inputs for risk estimation. Market and default risk are computed and these individual measures are aggregated to provide a total risk figure.[12] For each scenario, this risk estimation process is performed at discrete intervals over the five-year horizon and an evolution of the risk profile is generated for each scenario, based on the projected balance sheet for that scenario.

4.3 Summary of Capital Assessment Framework Risk Modelling

Table 2 provides a summary of the risk modelling approach employed within the capital assessment framework, to estimate the Central Bank's market and credit risks. The framework includes a bespoke approach towards the risk measurement of lending to counterparties, where an internally developed Credit Default Swap (CDS) based methodology is applied. Under this approach, instead of a specific collateral pool being linked to a loan, a hypothetical CDS contract is purchased from a notional third party, resulting in the modelling of a synthetic loan (see Christofides *et. al.*, 2015).

The underlying models used are calibrated using historical data and are complemented with expert judgement. While market and credit risk are calculated separately, the underlying inputs and settings are calibrated to provide consistency between the two models and this approach is under on-going refinement. As noted, interest rate mismatch risk is measured separately using an ALM model and is considered in conjunction with the market and credit risk methodologies to provide an overall risk assessment.

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12 Expected shortfall at a 99% confidence level (ES99) is the focal point of internal risk analysis for the Central Bank.

Table 2: Market and Credit Risk Modelling Summary

	Market Risk	Credit Risk
Portfolios Modelled	MTM portfolios (including investments, equity and the Special Portfolio)	All investment and monetary policy portfolios, all lending to counterparties and the Special Portfolio
Key Risk Driver	Volatility	Credit Rating
Risk Measure	1-year ES99	1-year ES99

5. Conclusion

Changes to NCBs' operating environments and policy approaches since the onset of the global financial crisis has had a significant effect on the size, composition and risks of their balance sheets. While central banks may theoretically be able to operate with negative capital, should risks be realised such that substantial losses occur, their independence, policy effectiveness and credibility may be compromised. In this context, NCBs have been paying much closer attention to the measurement of risks on their balance sheets in recent years.

The Central Bank has similarly developed its risk measurement tools during this period. The introduction of risk provisions has been a notable feature in recent years, and a broader framework has been introduced which facilitates a more risk-based assessment of the Central Bank's financial buffers position. The use of stress scenarios, as well as the application of a multi-year, dynamic balance sheet approach to estimating the Central Bank's risks, serves as an important guide to determining the adequacy of the Central Bank's capital and reserves.

The stress scenarios, underlying methodology and subsequent results serve as inputs into the Central Bank's profit appropriation decision, which is considered in the context of the Central Bank's current financial buffers and against its own risk appetite and internal policies, whilst also bearing in mind the distinction between avoidable and unavoidable risks.

It is also worth noting that the Central Bank's profits have been sizeable in recent years, but are expected to reduce significantly, following the full disposal of the Special Portfolio. After profits normalise, the Central Bank will be constrained in its ability to materially increase its capital and reserves to protect against potential risk exposures. Therefore, the recent practice of retention of the maximum allowable percentage of profits, which are transferred to the general reserve, serves as an important contributor to the Central Bank's overall financial buffers following the financial crisis. The introduction of a general risk provision in the 2016 Annual Accounts has also helped to improve the Central Bank's buffers. In combination, these measures will help provide the basis for the Central Bank's financial resilience and protect its continued independence in the years ahead.

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